HUMAN FACTORS AND TRAINING ISSUES IN CFIT ACCIDENTS AND INCIDENTS

Capt. Daniel Maurino
Secretary, Flight Safety and Human Factors Study Group, ICAO

INTRODUCTION

Controlled flight into terrain (CFIT) accidents and incidents are those in which an aircraft, under the control of the crew, is flown into terrain (or water) with no prior awareness on the part of the crew of the impending disaster (*Wiener, 1977*). Recent statistics suggest that close to 45% of aircraft losses during the period 1979-1990 can be accounted under this category (*Flight Safety Foundation, 1992*). This has led major international organizations, including the International Civil Aviation Organization (ICAO), the Flight Safety Foundation (FSF) and the International Air Transport Association (IATA), to multiply their endeavours destined to reduce CFIT accidents and incidents.

Concern over CFIT occurrences was first reflected in regulations after a B-727 struck a mountain during a non-precision approach to Dulles, Virginia. A premature descent was attributed to ambiguous pilot-controller communications and unclear information in the approach chart (*NTSB-AAR-75-16*). This was one in a series of accidents in which otherwise airworthy aircraft were flown into the surface by properly certificated flight crews. Implementation of the Ground Proximity Warning System (GPWS) requirement for large, turbine-powered airplanes engaged in international operations (*ICAO Annex 6, 1978*) and its ground counterpart, the Minimum Safe Altitude Warning (MSAW) as a feature of the automated radar terminal system (ARTS-3), were deemed the solution to preclude this type of accidents (*Loomis and Porter, 1981*). Although GPWS has reduced the incidence of CFIT occurrences, on balance it is a fair assessment that it has fallen short of fulfilling the expectations with which it was introduced. *Slatter (1993)* provides an excellent account of the shortcomings in the introduction of the GPWS as well as operational solutions to improve GPWS effectiveness as a safety net.

During the 1980's, enthusiasm regarding Human Factors led industry efforts to try to find solutions to CFIT occurrences through enhanced flight crew performance. The accident in which a DC-8 crashed during approach to Portland, Oregon, after running out of fuel (*NTSB-AAR-79-7*), was one of several approach and landing CFIT occurrences attributed to breakdowns in flight crew coordination and discipline. It acted as a trigger. Dedicated Human Factors training for flight crews, namely crew resource management (CRM) and Line-Oriented Flight Training (LOFT) (*Cooper, White and Lauber, 1979; Lauber and Foushee, 1981; Orlady and Foushee, 1986, Helmreich, Kanki and Wiener, 1993*), emphasizing the need for improved intra-cockpit communication, exchange of relevant operational information and situational awareness boomed across the airlines. This was accompanied by the inevitable exhortations about cockpit discipline and professional behaviour, elusive terms which escape sound definition and only generate unimaginative solutions with rather dubious results. As with GPWS, although the contribution of CRM and LOFT to aviation safety has been monumental, the pervasiveness of human error in CFIT occurrences suggests that Human Factors training is only a partial solution to CFIT occurrences.

Reducing CFIT occurrences requires recognition that such accidents and incidents are system-induced (*Wiener, 1977*), i.e., they are generated by shortcomings in the aviation system, including deficiencies in the organizations which constitute it. The accident in which a DC-10 crashed into an active volcano in Antarctica (*Aircraft Accident Report No. 79-139*) because of incorrect coordinates in its computer-generated flight plan has been asserted as an example of these shortcomings and the systemic nature of CFIT occurrences (*Mahon, 1981; Vette, 1984; Johnston, 1985; Mcfarlane, 1991*). Deploying people and funds -- always finite resources -- in furthering regulations, design or training will not likely improve CFIT statistics. Remedial and reform actions (*Reason, 1990*) aimed at reducing CFIT should address system failures and organizational deficiencies, since these are the areas where the greatest gains in safety improvement can be realised.

BACKGROUND

In dealing with CFIT occurrences, the industry followed a time-honoured approach. Upon observing one particular safety deficiency (CFIT), remedial action directed to operational personnel, essentially backwards-looking and aimed only at that deficiency led to regulations (Annex 6 and others), design (GPWS and MSAW) and training (CRM and LOFT). Remedial action based on regulations, design and training has worked reasonably well in the past, while the level of technology aviation employed to achieve its production goals (transportation of people and goods safely and efficiently) was relatively low, and the interactions between people and technology simple and predictable. On the other hand, the relatively unsophisticated level of technology utilized up to the 70's imposed considerable limitations on system goals, which in turn denied the system opportunities to foster human error. Examples of these limitations include, among others, simple air traffic control systems, high weather minima, operations restricted to visual conditions, flexible schedules, shorter legs, more layovers which alleviated circadian disrhythmia and simple equipment, transparent in use, demanding basic cognitive skills and responding to simple, well-rehearsed mental models.

Although systemic elements can be found in accidents and incidents since the beginning of aviation, human error in those times of low technology was more a consequence of operational personnel improperly applying their acquired knowledge and skills -- or not applying them at all -- because of shortcomings in equipment design, deficient training or silent regulations rather than induced by stringent system demands. Within this context, strengthening or adding local defenses (*Maurino, 1992*) through regulations, design or training appeared a sensible approach to follow. Such an approach provided considerable yields and elevated aviation to its status as the safest mode of transportation. The pitfall behind this progress is that every single piece of equipment designed and conceived to provide wider berth to human error eventually imposed greater demands over the very humans they were supposed to alleviate, by increasing system production demands. Technical advances are never used to increase the safety of the aviation system as a whole by creating wider safety margins. They are used to stretch system limits, leaving safety margins largely unchanged.

Aviation in the 90's has become an extremely complex system. It is also very sensitive, in the sense that even the smallest interference can lead to catastrophic consequences. In the quest to minimise human error and maximise production, high-technology has been introduced in large scale. Those who watched this introduction with impartial judgement suggest two basic flaws in it: (1) such introduction was technology-driven rather than

human-centred (*Billings, 1992*), and (2) it stopped short at the micro rather than at the macro level of system design analysis (*Meshkati, 1992*). The consequence of the first point is that technology, rather than eliminating human error, has merely displaced it (*Wiener, 1988*). The absence of macro analysis in the introduction of technology makes the system complicated and difficult to grasp conceptually rather than simple and easy to understand. New high technology is inherently opaque. The consequences of the interactions among people, technology and other system components in the safety of the system remain largely unknown (*Reason, 1992*).

People and technology interact at each human-machine interface. Both components are highly interdependent, and operate under the principle of joint causation (*Pidgeon, 1991*), i.e., people and machines are affected by the same causal events in the surrounding environment. Furthermore, these interactions do not take place in a vacuum, but within the context of organizations, their goals, policies and procedures (*Bruggink, 1990*). Understanding the principle of joint causation and the influence of the organizational context upon the aviation system operations is central to understanding CFIT occurrences and their prevention. Observing joint causation will avoid the piecemeal approaches based on design, training or regulations which have plagued past safety initiatives. Looking into the organizational context will permit to evaluate whether organizational objectives and goals are consistent or conflicting with the design of the organization, and whether the operational personnel has been provided with the necessary means to achieve such goals.

DISCUSSION

The success of the windshear training aid package (*FAA, 1987*) in reducing windshear-induced accidents has lured the aviation community into adopting similar approaches to other observed safety deficiencies. The recently produced takeoff training aid package (*FAA, 1992*) stands as a good example, and it will undoubtedly contribute in reducing aborted takeoff, overrun accidents. Not surprisingly, many advocate for a training package to reduce CFIT occurrences. It is asserted, however, that neither technical nor Human Factors training are *the* solution to reduce CFIT statistics. Furthermore, any CFIT training package would be redundant with existing training curricula and therefore an unnecessary and unproductive waste of resources.

The success of the windshear -- and hopefully the takeoff -- training aids resides in the fact that both windshear and aborted takeoff occurrences are specific situations, with inherent factors which can be punctually addressed. In both cases specific knowledge must be acquired, specific skills have to be developed and mental models must be revised. Examples of such punctual knowledge include understanding the dynamics of windshear, the consequences in terms of aircraft performance as well as the aerodynamics involved in an encounter, the certification conditions behind demonstrated takeoff distances, the sequence of controls selection or movements, etc. Specific skills must be developed and mental models changed to fly at high body angles, to "fly the stickshaker", to apply maximum braking, etc.; improper application of punctual knowledge or skills specific to these situations may trigger occurrences.

There are no factors inherently specific to CFIT occurrences. All the factors listed as contributing to CFIT occurrences (*Slatter, 1993*) are currently addressed by existing training curricula: navigational errors, non-compliance with approach or departure procedures, altimeter setting errors, misinterpretation of approach

procedures, limitations of the flight director/autopilot, etc. All these factors are addressed either during ground school or simulator training. Those factors not covered by technical training are included in CRM training: maintenance/loss of situational awareness, deficient intra-cockpit interaction, flight crew communications etc. A dedicated training package would be a meagre contribution to reduce CFIT occurrences.

The answer to CFIT occurrences lies in looking at them from a systems perspective, and act upon the latent failures which have slipped into the system, ready to combine with operational personnel active failures and, further compounded by adverse environmental conditions, may combine to produce an accident (*Reason, 1990*). Examples of these latent failures include poor strategic planning of operations, absence of clear channels of communication between management and operational personnel (a widely lamented but seldom acted upon, typical system failure), deficient standard operational procedures (a direct consequence of the aforementioned), corporate objectives which are difficult or impossible to achieve with existing resources and corporate goals inconsistent with declared safety goals, among others. It is impossible to act upon a problem unless awareness about it is gained. Therefore, it is advanced that the first answer to reduce CFIT occurrences is education. Education and training are terms loosely used among operational personnel. They are, however, quite distinct and certainly not interchangeable (*ICAO, 1989*). While familiar with training, operational personnel is seldom exposed to education, since it is assumed that it forms part of the basic individual baggage everyone carries before being hired. Given the complex and opaque nature of today's aviation system, it has been suggested that it is time to review the need to further education in aviation (*Kantowitz, 1992*).

Rather than a training package, what is needed to decrease CFIT events is an educational package, directed both to management and operational personnel, to acquaint them with the concepts of high technology system failures, how they manifest through organizational deficiencies, how they may lead to incidents and accidents and the ways to cope with them. The second answer is to take into account Human Factors considerations during system design, both at the micro and macro level. At the micro level, the Human Factors analysis must go beyond knobs and dials in the traditional ergonomic sense, towards the more complex cognitive, information-processing and communication processes between people and between people and technology. At the macro level, the interface between the human-machine sub-system must be considered within the context of the aviation system as a whole, including the declared system goals and the resources allocated to achieve them. If education takes place, this second step is perfectly achievable.

A CASE STUDY

On 15 November 1975, a Fokker F-28 Mk1000 with six crew members and sixty-five passengers on board crashed while attempting to land, following a circling, non-precision night approach in poor weather conditions at Concordia, Argentina (*Exp. No.xx/xx, JIAAC*). In a "textbook" approach and landing, CFIT accident, the aircraft hit the densely forested, sloping terrain less than one mile short of the intended landing runway. The aircraft was completely destroyed, and although there were three injured (one of them the captain) there were no fatalities. The investigating agency took the view that the accident was attributable to pilot error. The pilot was fined by the civil aviation authority and demoted by the airline. Eventually -- and after duly receiving additional training -- he was re-instated to captaincy. Less than appropriate consideration was given to the difficulties of

the immediate environment, replete with visual illusion-inducing conditions and with precarious navigation and approach aids. Neither did the investigation addressed the reasons which induced the crew to attempt an approach in such adverse conditions. The safety and prevention lessons which might have been learnt were effectively buried by the honest, but undoubtedly misdirected investigation, limited to the cockpit activities immediately preceding the accident.

When looking at this accident from an organizational perspective, multiple latent failures within the airline become evident. The most obvious organizational deficiencies include lack of strategic planning regarding the F-28 operation and incompatibility between the corporate goals assigned to the F-28 fleet and the resources provided to achieve them. The F-28 had recently been introduced into the airline and the process had been plagued with problems, including the adequacy of the qualifications of the airline training staff as well as the stability of the training organization. Ground school was conducted in-house with inappropriate means and with scant consideration paid to the fact that student captains had no previous jet experience and student first officers were being inducted into the airline. No flight simulator was available at that time, so all training was conducted in the aircraft, with its inherent limitations. Line-indoctrination was hurriedly completed due to the pressing need for crews to meet an ambitious commercial schedule, notwithstanding the mentioned lack of jet experience.

Management's inability to establish clear lines of communication with operational personnel was another serious organizational deficiency. This translated into deficient crew scheduling and pairing, improper consideration to environmental and equipment limitations when scheduling regular commercial services into destinations with doubtful infrastructures and unfriendly environments and, most important, an absolute lack of guidance to flight crews in terms of standard operational procedures as well as the limitations inherent to the operations. Because of these deficient lines of communications, newly qualified flight crews had no clear guidance as to which were the operational behaviours management expected from them. This lack of guidance -- and support -- has been recognized as an organizational failure which contributes to flawed decision-making by operational personnel (*Moshansky, 1992*).

Lack of strategic planning, incompatible goals, failure to communicate goals and to properly train personnel to achieve them are but a few examples of latent failures. They generate working environments replete with conditions which foster human error. Most important, such environments oftentimes make violations inevitable if tasks are to be achieved. An example of violation-producing conditions are those air traffic control procedures which generate nuisance GPWS warnings. Unless revised, they force crews to ignore warnings, thereby generating violations to operational orders to fulfil such procedures. Eventually environment or task conditions which generate errors and violations lead to system-induced accidents. Accident databases are replete with CFIT occurrences which support this contention.

CONCLUSION

When looking for solutions to CFIT occurrences, it is imperative to think in collective rather than individual terms (*Beaty, 1991*). It is naive to brand an entire professional body as being mainly responsible for aviation safety. It is equally impossible to anticipate the many disguises human error may adopt to bypass even

the most cleverly designed safety devices. Lastly, it is an unattainable goal to eliminate all system deficiencies leading to accidents.

The solution rests in securing a maximum level of system "safety fitness" (*Reason, 1992*), by working upon latent system failures, such as incompatible goals, poor communication, inadequate control, training and maintenance deficiencies, poor operating procedures, poor planning and other organizational deficiencies which modern accident causation approaches syndicate as responsible for disasters in high technology systems.

Periodic checking of these system "health condition" markers and continuously actioning upon them remain the single most important keys to reduce CFIT occurrences.